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ORIGINAL ARTICLE

Influence of load intensity on blood pressure after a resistance training session

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Abstract This study aimed to compare the blood pressure responses in normotensive-trained men following resistance training (RT) experimental sessions with loads of 60% and 80% of a one-repetition maximum. Ten participants underwent three experimental condition: (P60) – session adjusted with 60%, (P80) – session adjusted with 80% of 1 repetition maximum (1RM) and, (CONT) – only blood pressure assessments in rest condition for 60 min (intervals of 10 min). The resistance training design was adjusted with 3-sets, 3-min rest interval length between sets and exercises. Blood pressure was measured before, and at 10, 20, 30, 40, 50, and 60 min after the training session. The results showed that both protocols induce post-exercise hypotension ($p < 0.05$) compared to the rest values. The P80 showed greater magnitude and duration of post exercise hypotension when compared with P60 protocol ($p < 0.05$). In conclusion, resistance training is effective to provide a post exercise hypotension independent of the load intensities. This study is important to show the importance of control of the load intensity during development of resistance training programs and, the RT with 60% of 1RM can be as effective as protocols with 80% of 1RM to prevent the high blood pressure.

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La influencia de la intensidad de la carga sobre la presión arterial después de una sesión de entrenamiento de fuerza

Resumen Este estudio tuvo como objetivo comparar la respuesta de la presión arterial en los hombres normotensos entrenados realizando sesiones experimentales con cargas del 60 y el 80% de una repetición máxima. Diez participantes se sometieron a 3 condiciones experimentales: P60 (sesión realizada con el 60%); P80 (sesión realizada con el 80% de una repetición máxima [1RM]), y CONT (solo las evaluaciones de la presión arterial en el estado de reposo durante 60 min [intervalos de 10 min]). El protocolo experimental se llevó a cabo con 3 series, con intervalo de 3 min entre las series y los ejercicios. La presión arterial se midió antes y a los 10, 20, 30, 40, 50 y 60 min después de la sesión de entrenamiento. Los resultados mostraron que ambos protocolos indujeron hipotensión postejercicio ($p < 0,05$) en comparación con los valores en reposo. El P80 mostró una mayor magnitud y duración de la hipotensión postejercicio en comparación con el protocolo P60 ($p < 0,05$). En conclusión, el entrenamiento de fuerza es eficaz para proporcionar hipotensión postejercicio independientemente de la intensidad de la carga. Por lo tanto, en esta investigación es importante mostrar la relevancia del control de la intensidad de la carga durante el desarrollo de los programas de entrenamiento de fuerza. El entrenamiento de fuerza con el 60% de 1RM puede ser tan eficaz como los protocolos con 80% de 1RM para prevenir la presión arterial alta en los hombres.

Introduction

High blood pressure (HBP) is considered an important public health problem and the prevalence in worldwide is dramatic.[1] To prevent the HBP has been suggested changes in lifestyle and control of risk factors.[2] Furthermore, the physical exercise must be included as a non-pharmacological strategy to prevent and control this chronic disease.[3,4]

Several evidences have shown positive associations between physical exercises (aerobic, neuromuscular and neuromotor fitness) and post-exercise hypotensive responses (PEH).[5–7] The PEH is an important physiological response and there is a significant relationship with a prevention of cardiovascular events like strokes and coronary arterial diseases. Therefore, resistance training (RT) may represent an important strategy for public health and quality of life for everyone.[8–10]

Previous studies have examined PEH following RT sessions performed in different formats, such as a circuit training,[11] different numbers of sets,[12] different rest interval length,[13,14] different exercise order[15,16] and load intensity.[6,7,17]

However, few studies have compared the effect of different load intensity on blood pressure responses and, there are controversies in literature about this variable.[18]

Figueiredo et al.[17] analyzed the effect of three different load intensities (60%, 70% and 80% of 1 repetition maximum (1RM) with 8–10 repetitions per set) on PEH in prehypertensive trained men, and showed significant differences in the duration of the PEH when the 70% of 1RM loads were applied in a RT session, independent of the total volume. These results suggesting that moderate to high intensities could induce a better PEH response in trained men. In addition, Simão et al.[11] analyzed the effect of two different load intensities (6RM vs. 12RM with 50% of a 6RM) in normotensive-trained men, and showed no significant differences in duration of PEH between experimental sessions, independent of the total volume.

These results have shown that low or high intensities could induce PEH responses. On the other hand, Duncan et al.[7] compared different RT intensities on PEH and showed significant results only in group with high intensity (80% of 1RM). Moreover, Bentes et al.[16] did not showed differences between to intensities (60% and 80% of RM) on PEH. Yet, there is no consensus in the literature regarding the effects of RT load intensity on PEH.[12,18]

Must still be developed researches with objectives to analyze the PEH and, it has a significant value for conditioning and research of RT and to help coaches and other professionals to prescribe with security the RT programs for anyone. Therefore, the purpose of this study was to compare BP responses in normotensive-trained men following RT experimental sessions with loads of 60% and 80% of a 1RM. It was hypothesized that high intensity can promote longer PEH than low intensities.

Methods

Participants

Ten trained men with at least five years of recreational experience in RT volunteered for the study. Participants were recruited according to the criteria established by the Seventh Joint National Committee.[19] Prior to subject participation and data collection, all participants answered the Physical Activity Readiness Questionnaire and signed an informed consent form according to the Declaration of Helsinki. The exclusion criteria for the study were: (a) use of medication affecting their cardiovascular responses and

(b) existence of musculoskeletal or cardiovascular problems that might influence the performance of the proposed exercises. The study procedures, possible risks and benefits were informed for all the participants, and they signed an informed consent form. All participants were asked to not ingest caffeine or alcohol during the 24-h period, and not perform any vigorous physical activity during the 48 h prior to any testing protocols. None of the participants had any recent history of upper or lower body injury. During the experiment, participants were instructed to continue their typical diet in order to maintain their individual routines and not cause abrupt changes in resting metabolism. The research project was approved by the University Ethics Committee under 11176113.0.0000.5257 protocol number.

Experimental design

A repeated measures design trial was used to investigate the hypotensive effects of two intensities (60% and 80% of 1RM). The participants visited the Strength Training Laboratory five times. In the first visit, anthropometric measurements and one repetition maximum strength testing (10RM) were performed. In the second visit, re-test of 1RM in each exercise were carried out to analyze reliability.

All participants were then randomly assigned to the three experimental days: (P60) − all exercises adjusted with 60% of 1RM, (P80) − all exercises adjusted with 80% of 1RM and (CONT) − only BP assessments at 10, 20, 30, 40, 50, and 60 min in resting condition. The RT design for both experimental protocols progressed with each exercise performed separately in following sequence:

Leg Extension (LE), leg curl (LC), lat pulldown (LPD), bench press (BP), Biceps Curl (BC) and Triceps Extension (TE). On the third until the fifth day, participants performed one of the experimental protocols (P60, P80 and CONT). The RT design was adjusted with 3-sets, 3-min rest interval length between sets and exercises. The BP was measured at rest and after the training session ended. All the exercises were performed bilaterally. Were adopted 72 h between visits and during the exercise sessions, subjects were verbally encouraged to perform maximum repetitions in all sets. No pause was allowed between the eccentric and concentric phase of each repetition. During all RT sessions, participants were asked to avoid the Valsalva maneuver.

One repetition maximum test

To obtain reliable 1RM loads, data were assessed during two nonconsecutive days in the following exercise sequence: LE, LC, LPD, BP, BC and TE. To minimize the error during 1RM tests, the following strategies were adopted: (a) standardized instructions concerning the testing procedure were given to participants before the test; (b) participants received standardized instructions on exercise technique; (c) verbal encouragement was provided during the testing procedure; (d) the mass of all weights and bars used were determined using a precision scale. The 1RM was determined in fewer than five attempts with a rest interval of 5-min between 1RM attempts and 10-min was allowed before starting the 1RM assessment of the next exercise. The data of 1RM test were analyzed using intraclass correlation coefficients (LE $r = 0.982$, LC $r = 0.99$, LPD $r = 0.992$, BP $r = 0.997$, BC $r = 0.994$, TE $r = 0.981$) and showed high reliability. After the 1RM load in a specific exercise was determined, an interval of at least 10 min was allowed before the 1RM trial of the following exercise began. The individual being tested was instructed on the proper technique of the exercise execution and the highest load completed in both days was considered the 1RM.[20]

Arterial blood pressure assessment

Measurements of SBP, DBP were performed using an automatic oscillometric device (Omron Brand – BP785-10 – EUA). The equipment was auto calibrated before each use. Before the beginning of each experimental session, participants rested quietly in a seated position during 15 min, after which baseline blood pressure was measured. After each experimental session, blood pressure was assessed at rest and at 10, 20, 30, 40, 50, and 60 min after the training session, resulting in seven measurements. All participants remained seated during the BP assessments, each subject was tested under resting conditions at the beginning of the monitoring period (38), and this equipment was used for all pre- and post-session blood pressure measurements and was compared with a sphygmomanometer and auscultation methods. The cuff size and all measurements were performed on the left arm for every assessment followed the recommendations of the American Heart Association.[21]

Statistical analysis

The statistical analysis was initially performed using the Shapiro–Wilk normality test and the homoscedasticity test (Bartlett criterion). Blood pressure demonstrated normal distribution and homoscedasticity ($p > 0.05$). Three-way repeated measures ANOVAs (group [P60 vs. P80 vs. CONT] × time [rest vs. immediately after vs. 10 min vs. 20 min vs. 30 min vs. 40 min vs. 50 min vs. 60 min]) followed by Tukey's post hoc test were used for the analyses of possible differences in SBP, DBP, and MAP. The level of significance was set at $p < 0.05$. All statistical analyses were carried out using SPSS statistical software package version 20.0 (SPSS Inc., Chicago, IL).

Results

The subjects characteristics are shown in Table 1.

Tables 2 and 3 display mean and standard deviation values, as well as mean changes between each post-exercise value vs. baseline.

Table 1 Descriptive characteristics of the sample group.

Characteristics	M ± SD
Age	24.8 ± 2.9
Weight	77 ± 7.0
Height	174.3 ± 5.7
Body fat	10.7 ± 3.9
BMI	25.2 ± 1.2

M, mean; SD, standard deviation; BMI, body mass index.

Table 2 Systolic blood pressure values after the protocols Systolic blood pressure–mmHg (mean ± SD).

Time	Groups		
	CONT	P60	P80
Rest	122.4 ± 2.3	122.4 ± 2.5	122.6 ± 2.5
10 min	119.7 ± 2.0	117.3 ± 4.9	109.9 ± 7.2*,#,^
20 min	120.2 ± 1.7	111.4 ± 4.3*,^	104.7 ± 8.3*,#,^
30 min	120.9 ± 1.3	111.9 ± 6.5*,^	106.0 ± 7.4*,#,^
40 min	121.3 ± 1.3	111.3 ± 5.7*,^	104.1 ± 6.2*,#,^
50 min	121.7 ± 1.6	109.4 ± 6.9*,^	102.0 ± 6.4*,#,^
60 min	122.0 ± 1.8	113.1 ± 6.1*,^	100.7 ± 6.1*,#,^

* Significant difference from pre-exercise values.
\# Significant difference from P60.
^ Significant difference from CONT; SD, standard deviation.

Table 3 Diastolic blood pressure values after the protocols diastolic blood pressure – mmHg (mean ± SD).

Time	Groups		
	CONT	P60	P80
Rest	79.6 ± 3.0	80.0 ± 3.0	79.9 ± 2.7
10 min	77.4 ± 3.7	75.6 ± 4.9	72.1 ± 6.3*
20 min	78.0 ± 3.7	72.2 ± 5.7*,^	68.3 ± 5.4*,^
30 min	79.3 ± 5.6	73.0 ± 3.1*,^	67.9 ± 4.7*,#,^
40 min	80.2 ± 4.9	72.7 ± 4.0*,^	67.5 ± 6.2*,#,^
50 min	79.5 ± 2.7	71.7 ± 3.7*,^	65.8 ± 4.8*,#,^
60 min	79.3 ± 2.5	73.8 ± 3.6*,^	65.4 ± 5.9*,#,^

* Significant difference from pre-exercise values.
\# Significant difference from P60.
^ Significant difference from CONT; SD, standard deviation.

In CONT, no significant changes were observed in BP in timeline assessments ($p > 0.05$).

There was a significant two-way interaction for group × time ($p < 0.05$) for SBP and DBP. P60 showed hypotensive results for SBP (systolic blood pressure) and DBP (dyastolic blood pressure) after 20 min compared with the baseline values ($p < 0.05$, Tables 2 and 3). P80 showed hypotensive results for SBP and DBP after 10, 20, 30, 40, 50 and 60 min compared with the baseline values ($p < 0.05$, Tables 2 and 3), ($p < 0.05$, Tables 2 and 3).

P80 showed a significant difference in SBP at 10, 20, 40, 50 and 60 min between P60 ($p < 0.05$) (Table 2) and, in DBP the P80 group showed a significant difference at 30, 50 and 60 min between P60 ($p < 0.05$) (Table 3).

Discussion

The purpose of this study was to compare BP responses in normotensive-trained men following RT experimental sessions with loads of 60% and 80% of a one-repetition maximum. It was hypothesized that high intensity can promote longer PEH than low intensities. The main finding of this study was that both sessions were able to induce PEH in trained men. Both RT protocols showed a PEH, nevertheless, P80 showed a significant decrease when compared with P60. Moreover, P80 maintained significant decreases in BP compared with rest-values until 60 min. Therefore, our hypothesis was confirmed with P80 showed a longer PEH response.

Although, P60 has showed significant PEH compared with the baseline values, the P80 had significant decreases with major magnitude than P60. These results corroborate with a literature showing that during the RT sets, progressing until momentary muscle failure, might increase the cardiovascular responses interacting with an increases in BP.[22,23] Consequently, this study was able to identify significant PEH in P60, performed with lower cardiovascular stress during the session, and with significant reductions on the BP values. On the other hand, the P60 may have produced a lower training volume to stimulate a PEH magnitude like P80. Therefore, there is a significant association between the training volume in RT and a PEH is an important methodological variable of training to control, it was showed by Figueiredo et al.[12]

Duncan et al.[7] compared the PEH at different RT intensities, the results showed significant PEH after session in session with high intensity. However, Cavalcante et al.[6] compare the outcomes of differing intensities of RT (40% and 80% of 1RM) on twenty hypertensive older women and the results showed that hypertensive older women exhibit PEH independently of exercise intensity. Wherefore, the load intensity of RT is one of the methodological variables of the training prescription that can influence PEH. However, there are evidences showing there are other factors as to the sample group as training volume, age and training level which may affect the main outcomes.[18]

In our study, the sample characteristic was similar with Duncan et al.[7]. Participated in both studies youth men with previous experience in RT and, may be low-intensity (40% of 1 RM), used for Duncan et al.[7] was not sufficient to cause significant PEH.[17]

These results showed several divergences in scientific literature about load intensity. There is significant PEH with low intensities (40–60% of 1RM) with older women and detrained samples; however, with trained men low overloads do not induce a PEH. Consequently, according with the previous results, there is a load intensity threshold for each training level. Duncan et al.[7] controlled the number of repetitions to avoided discrepancies in total work between intensities. Nonetheless, in present study all participants performed until momentary muscle failure, suggesting that the intensity of the session may have greater impact on PEH than the total work equalization.

Simão et al.[11] verified the acute effect of two different intensities (6RM to failure vs. 12 RM with 50% of a 6RM load) in normotensive trained men on PEH. The results showed no significant differences in the duration of the PEH response between experimental sessions, independent of the total volume load, suggesting that either low- or high-intensity loads may induce a PEH response. These results disagreed with our findings, in both researches the participants were trained, but our protocol were adjusted with large rest interval length (3-min between sets and exercises) to avoided any kind of confounding and, ensure the total recovery, the large rest interval might be influence in intensity of the session.

Although the rest interval length was not a main variable to influence the PEH response after a RT session,[13,14] may be that large rest interval length reduce the influence of load intensity and increase the performance between sets and exercises during the RT session, thereby, equalizing the perceived exertion notwithstanding in the two different intensities.[24-26]

Bentes et al.[16] compared different RT intensities and exercise order in trained women on PEH, and the results showed, in both intensities occurred PEH. These results corroborate with our findings, because the high overload (80% of 1RM.) showed a prolonged magnitude of PEH than a low overload (60% of 1RM). Although, there was no significant differences between exercise order. Accordingly, the protocol with 60% of 1RM might be associated with a PEH. Furthermore, the present results corroborate with other studies, suggesting that in acutely approaches regardless of gender, PEH are not associated with a load intensity, in other words, both intensities have influence on PEH.[16-18]

Our results, showed that P80 produce a prolonged magnitude of HPE than P60, notwithstanding it has a significant representation in cardiovascular protection, suggested by American College of Sports and Medicine and American Heart Association.[3]

Conclusion

Accordingly, with our results, RT is effective to provide PEH independent of the load intensities. Thereby, this research is important to show the importance of control of the load intensity during development of RT programs and, the RT with 60% of 1RM can be effective such as protocols with 80% of 1RM to prevent de HBP.

Conflict of interest

The authors have no conflicts of interest.

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